REMARKS:

Claim 23 is objected to on the ground that the limitation "the prism" has no antecedent basis. Claim 23 has now been amended so that the limitation does have sufficient antecedent basis in the claim.

Claims 1-43 are rejected under 35 USC 102 (b) as being anticipated by U.S. Patent 5,171,999 to Komatsu, et al. ("Komatsu"). The rejection is traversed insofar as it applied to the claims as amended.

Claims 1, 19, 39, 41-43 have now been amended to require that the radiation illuminating the two structures propagates along paths towards the structures and that the zeroth order diffraction of the radiation by the structures retraces such paths after diffraction by the structures. This means that the radiation illuminating the two structures are directed towards the structures in directions that are substantially perpendicular to the surface of the sample at which the two structures are located. As amended, the invention of claims 1, 19, 39 and 41-43 are radically different from that of Komatsu.

Thus, as is clear from column 9, lines 30 through column 10, line 5, the diffraction grating mark RM on the reticle is illuminated from two different directions making a predetermined intersection angle therebetween. In the same vein, the diffraction grating mark WM on the wafer is also illuminated in two directions making a predetermined intersection angle between the two directions. The intersection angle between the two directions with respect to the mark RM is selected so that the +1 order diffraction reflected light as well as the –1 order diffraction reflected light by the diffraction grating mark RM pass in a direction substantially perpendicular to that of the reticle and in the direction of the optical axis of the optical system. Similarly, the intersection angle between the two directions of illumination with respect to the mark WM is selected so that the +1 order diffraction reflected light as well as the –1 order diffraction reflected light by the diffraction grating mark WM pass in a direction substantially perpendicular to that of the wafer surface and in the direction of the optical axis of the optical system.

As will become clear in the discussion below in regard to U.S. Patent 5,751,426 to Nose ("Nose"), in order for the +1 and –1 diffraction orders to be perpendicular to the surface of the wafer and of the reticle as a result of two oblique illumination beams, the angles of incidence of the two directions of illumination must be selected properly. For example, in order for the +1 and –1 first order diffractions to be perpendicular to the surface, the angle of incidence of illumination depends upon the pitch of the diffraction grating RM on the reticle and WM on the wafer. In other words, when the optical system proposed by Komatsu is used to inspect reticles and wafers with diffraction marks of different pitch, the angle of incidence of illumination in the two directions must be altered so that the first diffraction orders will be diffracted in a direction perpendicular to the surface of the reticle and of the wafer. This is of course, a cumbersome and time-consuming process.

In contrast, the invention of claims 1, 19, 39 and 41-43 has no such disadvantages. In these claims, the illumination radiation propagates along paths towards the structures so that the zeroth-order diffraction of the radiation by the structures retraces such paths after diffraction by the structures. This means that the radiation is directed towards the inspected surface so that it propagates along paths that are substantially perpendicular to the structures. The first order diffractions of such radiation by the two structures are therefore at angles oblique to the surface of the structures. Even though the directions along which the +1 order and the –1 order diffractions are also dependent upon the pitch of the two structures, as long as the numerical aperture of the collection optics is adequate to collect the first order diffractions despite the change in pitch, there is no need to adjust or alter the directions of the illumination beams when different wafers with diffracting structures of different pitches are measured.

In view of the above-described differences between claims 1, 9, 39 and 41-43 on one hand and Komatsu on the other, it is believed that these claims are patentable over Komatsu. It is believed to be well-settled that in order for a reference to anticipate a claim, there must be identity of elements between the elements of the claim and those of the reference. Komatsu clearly fails this test.

As noted above, Komatsu fails to teach the limitation that the illumination radiation propagates along paths across the structures and zero-ordered diffraction of the radiation by the structures retraces such paths of the diffraction by the structures.

Thus the system of claims 1, 19, 39 and 41-43 has the advantage that there is no need to adjust the illumination direction when the pitch of the structures changes. Furthermore, unlike the system of Komatsu, since the diffractions by each of the two structures are along different directions, the diffraction by the two structures will result in four different diffraction beams which are combined for determining misalignment between the structures. In one embodiment, the steps through which these four beams are formed and then combined is illustrated in Fig. 4. In contrast, since the first positive and negative diffraction orders of Komatsu when two different beams are diffracted by the same structure propagate along the same direction, there is no need to recombine the two beams for measuring misalignment. In view of the vast differences between the above-described differences between the system of the rejected claims of 1, 19, 39 and 41-43 on the one hand and Komatsu on the other, it is believed that there is no reason or motivation to alter Komatsu's system so as to arrive at the invention of these rejected claims. Therefore, it is further believed that claims 1, 19, 39 and 41-43 are non-obvious over Komatsu.

Claims 2-18, 20-38 and 40 are believed to be allowable over Komatsu since they depend from claims 1, 19, 39 or 41-43. They are further believed to be allowable because of the features in these claims. Claim 9 adds the feature that the combined beam from claim 7 is divided into the first and second beams as specified in claim 2. Komatsu fails to teach or suggest such a feature. It is noted that even though Komatsu used lens 21 to converge two beams onto diffraction grating beam 22, the combined beam is not subsequently divided into two separate beams for separately illuminating two structures as specified in (see claim 2), claim 9. Claim 13 has been amended to clarify that there is relative motion between the element and the structures when diffractions from the structures are detected. This is not taught or suggested by Komatsu. The stepping of the wafer referred to in column 7, line 45 of Komatsu is merely to move the wafer between different shot positions, where no diffraction is detected when the wafer is stepped. As illustrated in the embodiment of Fig. 6 and described in the specification on pages 9 and 10 of the present application, by moving the element (such

as prism 32), the detected diffraction radiation signals are functions of the displacement of the element, so that it is possible to calculate a phase difference between the diffraction radiation signals that are detected from the two structures when there is relative motion between the element and the structures. This is not the case at all in Komatsu, contrary to the opinion of the Examiner at the bottom of page 4 and the top of page 5 of the Office Action.

Claims 14 and 27 add the limitation that the first order diffraction signals from the two structures are combined. This is not the case at all in Komatsu, contrary to the opinion of the Examiner on page 5 of the Office Action. As clearly explained in column 9, lines 30-63, the positive and negative first order diffracted light from the grating RM pass in the direction of the optical axis of the system to reach a field stop 32 at detector 34. Similarly, the positive and negative first order diffracted light at the mark WM passes along the optical axis of the system and reaches a field stop 29 to reach the detector 31. See column 9, line 64 through column 10, line 17. In other words, in Komatsu, the positive and negative first order diffractions from the same grating RM are combined, and the positive and negative first order diffractions from the mark WM are also combined. This is very different from claim 14 where the first order diffraction signals from two separate diffracting structures are combined. The section in Komatsu on column 16, lines 34-38 referred to on page 5 line 4 of the office action discloses nothing more than the above-referenced feature where the first order diffractions from the same mark WM are combined.

Claims 15 and 28 add the limitation that the positive first order diffractions from the two structures are combined and that the negative first order diffractions from the two structures are combined. Komatsu clearly fails to teach or suggest such feature, contrary to the opinion of the Examiner on page 5 of the Office Action. As noted above, Komatsu combines the positive and negative first order diffractions from the same structure (from RM and from WM), and not the first order diffractions from two different structures.

Claim 18 adds the limitation that the two periodic structures are also periodic substantially along a second line transverse to the first line and wherein the determining determines misalignments between the structures along the first and second lines. This feature is illustrated in the embodiment of Fig. 13 of the present application. In reference to

Fig. 13, the two structures C and D are periodic along two different axes, where the two different axes are transverse to each other. This is not the case at all in Komatsu. As clearly illustrated in Figs. 22A and 22B, the grating lines in both marks RM and WM are parallel to the Y axis and are not transverse to one another. Therefore the two marks RM and WM are periodic only along a first line (the x- axis) and are not periodic along any second line transverse to the X-axis, contrary to the opinion of the Examiner on page 5 of the Office Action.

For substantially the same reasons as those explained above for claim 13, claims 22 and amended claim 26 are likewise believed to be allowable. For substantially the same reasons as those explained above for claims 15 and 18 respectively, claims 28 and 38 are likewise believed to be allowable. For substantially the same reasons as those explained above for claim 9, claim 35 is likewise believed to be allowable.

In regard to claim 23, the feature in this claim is illustrated in the embodiment of Figs. 7A and 7B of the instant application. The advantage of such feature is explained in the specification from page 10, line 17 through page 11, line 15. Wollaston prisms are normally designed such that one optical axis is parallel to its length in one half of the prism and another axis is parallel to the length in the other half of the prism, where the two halfs are separated by an optical interface. Such designs, however, may cause the two different polarizations of the beams split by the prism to have different diffraction efficiencies. This can cause an imbalance in amplitude between the two diffracted beams and limits the sensitivity of detection. The feature in claim 23 overcomes this problem by orienting the optical axis in one half of the prism at +45° with respect to its length in one half of the prism and the other axis at –45° to the length of the other half of the prism. Such feature is not taught or suggested at all by Komatsu, contrary to the opinion of the Examiner. If the Examiner disagrees, it is respectfully requested that the Examiner point out the disclosure in Komatsu and explain in detail why such action anticipates claim 23. It is noted that the optical axis of the prism is different from the interface between the two halves.

Claims 1-6, 10-32 and 36-43 are rejected under 35 USC 102(b) as being anticipated by U.S. patent 5, 751, 426 to Nose, et al. ("Nose"). The rejection is traversed insofar as it applies to the claims as amended.

Nose discloses an optical system somewhat similar to that of Komatsu. In particular, the two illumination beams Lf1 and Lf2 illuminate two diffraction gratings placed side by side at the same oblique angle of incidence (but from opposite sides) relative to the normal to the surface of the wafer so that the positive and negative first order diffractions from the two beams superimpose and are diffracted in a direction normal to the wafer surface. Thus, Nose shares the same disadvantages enumerated above for Komatsu, namely, that whenever the pitch of the diffraction gratings changes (such as when different grating structures are inspected), the angles of incidence of the two light beams Lf1 and Lf2 must be changed so that the positive and negative first order diffractions will continue to be diffracted in directions normal to the wafer surface insofar as the optical system is concerned. See, for example, equation 9 in column 7 of Nose, which equation sets forth the angle of incidence as a function of pitch. This procedure is cumbersome and time-consuming. Therefore, for substantially the same reasons as those explained above in reference to Komatsu, claims 1, 19, 39 and 41-43 are believed to be patentable over Nose.

The remaining dependent claims rejected in view of Nose are also believed to be allowable since they depend from allowable claims. These claims are also believed to be allowable on account of the features in these claims. For example, claims 13, 22 and 26 add the feature that there is relative motion between the elements and the structures when the diffracted radiation signals are detected. This permits a phase difference between the diffraction radiation signals to be detected or calculated for determining a misalignment between the two structures. Contrary to the Examiner's opinion at the bottom of page 7, column 1, lines 12-21 of Nose does not disclose such feature at all. If the Examiner disagrees, it is respectfully requested that the Examiner explain in detail why such section of Nose anticipates the above-described feature in claims 13, 22 and 26.

Contrary to the opinion of the Examiner, Nose fails to teach or suggest the feature of claims 15 and 28 where the positive first order diffractions of the first structures are combined and the negative first order diffractions from the two structures are combined. Column 4, lines 19-28 of Nose does not teach such feature of claims 15 and 28. If the Examiner disagrees, it is respectfully requested that the Examiner explain in detail why such section of Nose anticipates the feature of claims 15 and 28. In fact, in column 6, lines 43-50, Nose clearly states that the positive first order diffraction from the light beam Laf1 and the negative first order diffraction of the light beam Laf2 superimpose. In other words, in Nose, the positive first order diffraction of one light beam and the negative first order diffraction of the other light beam superimpose which is different from claims 15 and 28 where the positive first order diffractions of two beams superimpose and the negative first order diffractions superimpose.

Applicants also disagree with the Examiner in regard to the opinion on page 8 in regard to claims 18 and 38. In Fig. 2, the two gratings 2a and 2b are clearly periodic along the same line or direction (X-axis) only, and are not periodic along any second line transverse to the X-axis.

In regard to claim 23, the feature in this claim is illustrated in Figs. 7A and 7B of the instant application. The advantage of such feature is explained in the specification from page 10, line 17 through page 11, line 15. Wollaston prisms are normally designed such that one optical axis is parallel to its length in one half of the prism and another axis is parallel to the length in the other half of the prism, where the two halfs are separated by an optical interface. Such designs, however, may cause the two different polarizations of the beams split by the prism to have different diffraction efficiencies. This can cause an imbalance in amplitude between the two diffracted beams and limits the sensitivity of detection. The feature in claim 23 overcomes this problem by orienting the optical axis in one half of the prism at +45° with respect to its length in one half of the prism and the other axis at –45° to the length of the other half of the prism. Such feature is not taught or suggested at all by Nose, contrary to the opinion of the Examiner. If the Examiner disagrees, it is respectfully requested that the

Examiner point out the disclosure in Nose and explain in detail why such action anticipates claim 23.

To more completely cover the invention, new claims 44-52 have been added. For substantially the same reasons as those explained above for claims 1, 19, 39 and 41-43, claims 49 and 51 are likewise believed to be allowable. Dependent claims 44-48, 50 and 52 are believed to be allowable since they depend from allowable claims. They are further believed to be allowable since they add features which are not taught or suggested by either Komatsu or Nose. Thus, these claims add the limitation that less than the entire structure of the two structures is illuminated, so that the two illuminated portions are separated from each other and do not overlap. This is clearly different from Nose, as shown in Fig. 7 of Nose. As shown in Fig. 7 of Nose, both illumination beams Lf1 and Lf2 essentially overlap as indicated by the two unlabeled elliptical lines, one solid and one dotted. In other words, the two illumination beams overlap and the two illumination beams illuminate the entire structures 2a and 2b. As shown in Fig. 7 of Nose, the diffraction from structure 2a is reflected by mirror 11, thereby separating such diffraction from the diffraction from the diffraction from structure 2b. However, since both structures 2a and 2b located close to one another are illuminated in their entireties, diffraction from structure 2b can deviate from the normal direction to the wafer surface and be reflected by mirror 11. Similarly, diffraction from structure 2a can also deviate from the normal direction to the wafer surface and not be reflected by mirror 11 but become superimposed with the diffraction from structure 2b. The result is cross-talk which degrades the sensitivity of measurements. In contrast, in the new claims 44-48, 50 and 52, since less than the entire structure is illuminated and that the two illuminated portions are separated from each other and do not overlap, the above-described cross-talk problem is much reduced.

Claims 1-52 are presently pending in the application. Reconsideration of the rejections is respectfully requested and an early indication of the allowability of all the claims is earnestly solicited.

Respectfully submitted,

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